Formulation and Application of Metrics for Ocean Modeling

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LONG-TERM GOALS

The overall goal is to aid the performance and evaluation of ocean models used for nowcasting and forecasting by the Navy. More specific goals are the evaluation of global ocean models coupled to the atmosphere and to regional forecast models.

OBJECTIVES

The primary objective of this effort is the preparation and evaluation of metrics to evaluate the physical soundness and forecast accuracy of ocean forecast models. Two corollary objectives are the preparation of hydrographic data fields used in metrics applications and model evaluation, and of climatological fields used in POP (Parallel Ocean Program) model initialization and forcing.

APPROACH

Our approach has focussed on three tasks this fiscal year: (1) the building of monthly hybrid, high resolution climatologies from blended seasonal and monthly MODAS and PHC2 fields; (2) a review of the open boundary conditions used in one-way and two-way nesting of NRL models; and (3) application of metrics to evaluate the POP model in the GIN Sea.

WORK COMPLETED

1) Monthly hybrid, bottom-reaching, 1/8 deg climatologies were constructed from blending MODAS [ref. 1-3] and PHC2 [ref. 4-5] seasonal (to bottom) and monthly (to 1500m) fields. These removed some of the earlier deficiencies in the South Pacific and the Arctic.

2) Finished a survey of the use of metrics as applied to hydrography and transports in major model comparison efforts, with special focus on the American DAMEE [ref. 6] and European DYNAMO [ref. 7] projects, both involving simulations in the Atlantic Basin.

3) Completed the building of an extensive data set of hydrographic and drifter measurements in the GIN (Greenland-Iceland-Norwegian) Sea taken by the SACLANT Research Center in the years 1986-1994 [ref. 8-12].

4) Finished development of the mapping and interpolation routines needed to put the 1/3 deg POP global model output [ref. 13] and the hydrographic data on a common spatial grid, necessary for model verification.

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14. ABSTRACT
The overall goal is to aid the performance and evaluation of ocean models used for nowcasting and forecasting by the Navy. More specific goals are the evaluation of global ocean models coupled to the atmosphere and to regional forecast models.

15. SUBJECT TERMS

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5) Completed a hydrographic evaluation of the POP 1/3 deg model results in the GIN Sea [ref. 14].

RESULTS

A. Climatology Evaluation and Development: The Navy's 1/8 deg global MODAS (Modular Ocean Data Assimilation System) climatology [Ref. 1-3] was blended with the 1 deg global PHC2 climatology [Ref. 4-5] of the Polar Science Center of the University of Washington, in the latitude range 60N-80N. In the Arctic north of 80N, the PHC2 climatology was inserted. Monthly MODPOL climatologies were generated using the available monthly MODAS and PHC2 climatologies above 1500m depth, and interpolated from seasonal values below 1500m.

B. Model/Measurement Data Bases: The large in-situ data sets collected by the SACLANT Research Center and NRL in the GIN Sea, as well as the POP model output, were organized into two corresponding data bases with the same format and data structure, which made model-data comparison more accurate and much easier. Both serial CTD data and 3-D model output were arranged as sets of vectors on each depth level, e.g. T(nc,k) implying a vector nc long, with nc being the number of CTD or model data points in the set. and k denoting the depth level.

C. Pop Model Evaluation: This work proceeded along 2 lines. The major portion of the work was devoted to direct comparisons of the CTD/AXBT vectors and the interpolated model vectors. Since the 1/3 deg resolution of the first model examined [ref. 13] was only marginally eddy-resolving, and the solutions represented an 18-year simulation with no data assimilation (albeit driven with daily operational atmospheric fluxes), we decided to do the comparison as averages on 4x2 deg grid boxes that typically contained 10-20 data points and 30-40 model points. Figure 1 shows the comparison in the Iceland-Faroe Frontal area in the period June 1989. The illustrated area consists of a large box (14W-6W, 62N-66N), which is then divided into four sub-boxes. Results are shown for boxes 3 and 5, containing the largest number of observations. The respective horizontally averaged temperature profiles, down to a 1000m, are given in Fig. 1.

   The second part of the effort was to examine the long-term behavior of the model, in terms of interannual variability of transports across important passages and transects (.e.g. Faeroe-Shetland Channel, Iceland-Faroe Gap), of the volume mean temperature and salinities, as well as of the watermass census. Figure 2 depicts the interannual variation, from 1980-1997, of the mean temperature and salinity fields of the POP output along the transect 63N, 4W-6E, in the Iceland-Faroe Frontal area. A quantitative examination reveals a definite increase of temperature of the northward-flowing Norwegian-Atlantic Current from the 1980's to the 1990's, which could have contributed to the warming in the Arctic Ocean of waters of Atlantic origin in the early 90's These results have been presented at the WOCE/JGOFS Transport Workshop in Southampton, England, June 2001 [ref. 14], and agree in general with available measurements and other modeling results.

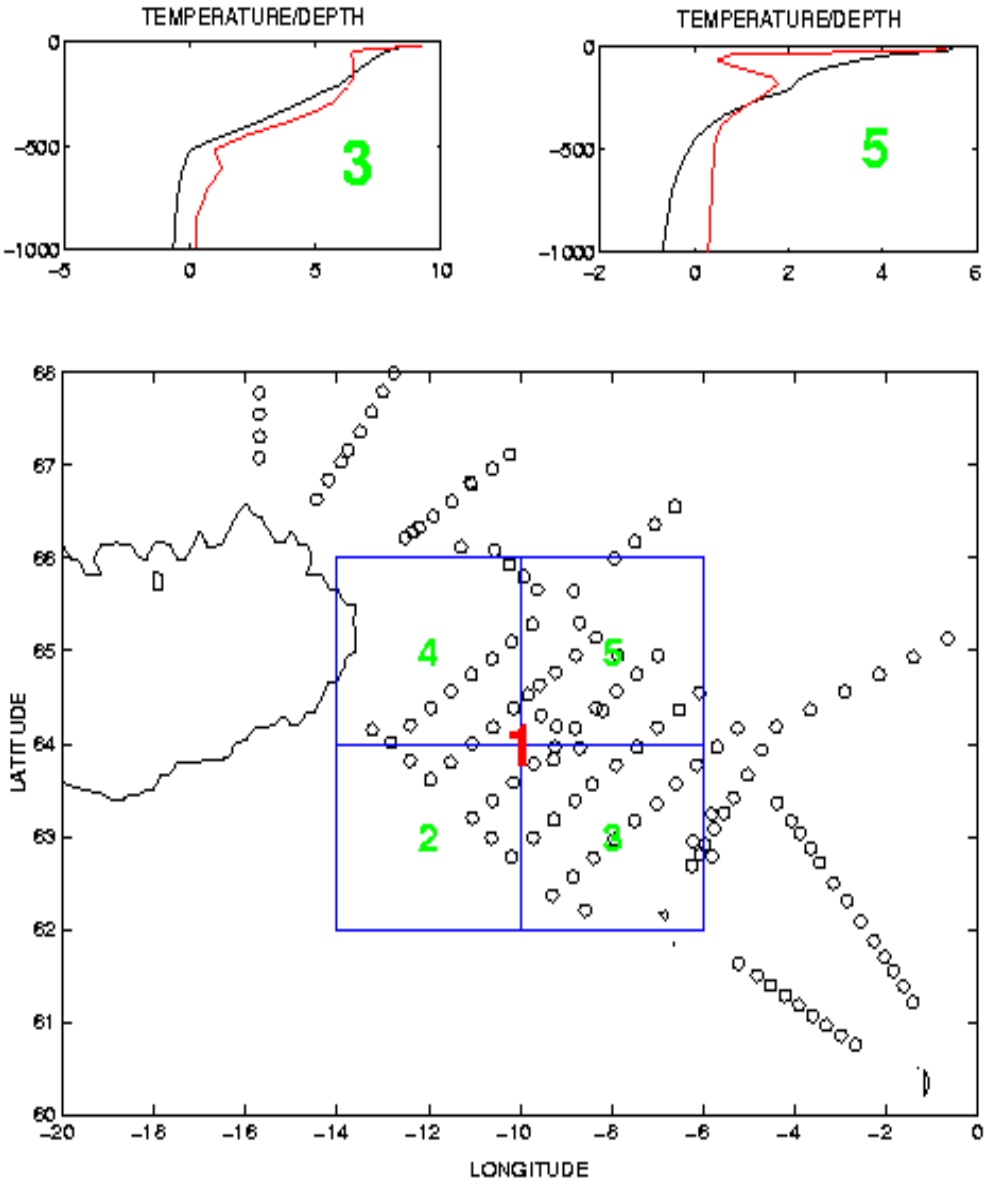

Fig. 1. A comparison of the box-averaged temperature vs. depth profiles in the Iceand-Faroe Frontal Area for the June 1989 period. Red lines: POP model output, black lines, CTD casts. The large blue box (extent 14W-10W, 62N-66N) is denoted Box 1, and the four sub-boxes are labeled 2 to 4. The respective box notation is indicated in each of the profile figures. The circles are locations of the June 1989 CTD's.

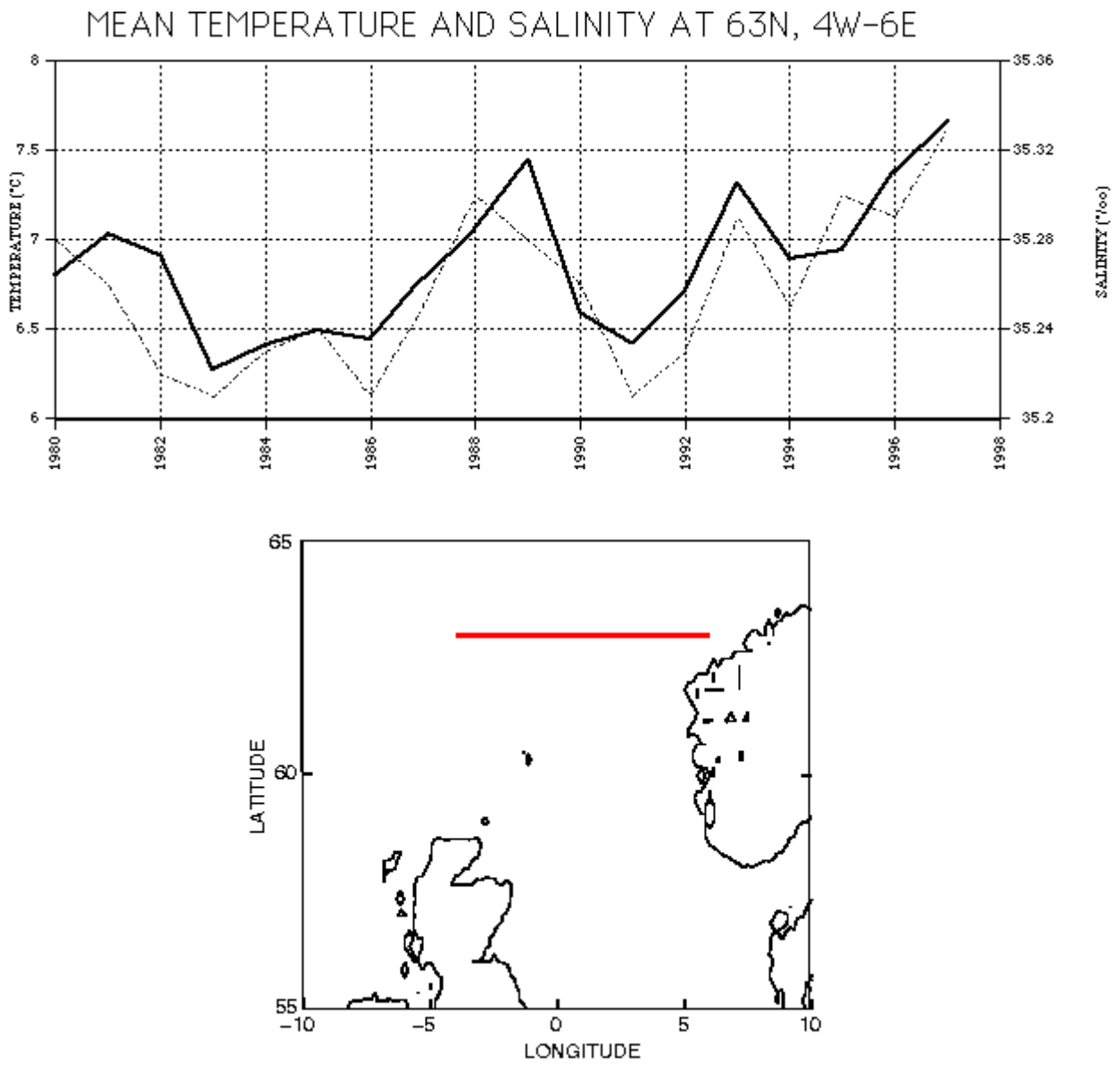

Fig. 2. Above: The interannual variation of mean temperature (solid line) and salinity (dotted line) fields derived from POP model output on transect 63N, 4.0W – 6E, at 200m depth. Below: Location of transect across the Norwegian Atlantic Current, from the Faroes to Norway (eastward continuation of June 1989 cruise also shown).

IMPACT/APPLICATION

The high resolution climatology will improve the spinup of the global model, particularly in the deeper waters. It will also aid in the simulation of the surface salinity field which undergoes a weak restoring to climatology. The formulated metrics for operational use will aid in synoptic forecast verifications, and the R&D metrics, along with the GIN Sea data base, will aid in the monitoring of longer-term model behavior. The data base will also be used to improve the MODPOL climatology in the Nordic-Arctic Seas.

TRANSITIONS

We have delivered monthly, hybrid, 1/8 deg global resolution climatologies to the POP modeling team (M.Maltrud of the Los Alamos National Laboratory [LANL] and J.McClean of the Navy Postgraduate School [NPS]), as well as to the NRL/NAVO development group for MODAS. The necessary blending and smoothing software has also been delivered to the latter team. A portion of the GIN Sea data set has also been delivered to the MODAS team.

RELATED PROJECTS

1. The development and testing of the global POP model in the Navy's coupled air-sea model (J.McClean, Naval Postgraduate School; M.Maltrud, Los Alamos National Laboratory). We are developing for the POP model climatologies for initialization and surface restoring, analyzed fields for data assimilation, and metrics and hydrographic data for model verification.

2. The development of global climatologies and synoptic oceanic analyzed fields within the MODAS (Modular Ocean Data Assimilation System) framework [C.Barron, NRL Code 7320, M.Carnes, Naval Oceanographic Office]. We use their products for blending into hybrid climatologies, and adapt their analyzed fields to the POP model setup.

3. The development of the PHC2 climatology [M.Steele, Polar Science Center, University of Washington. We use the PHC2 climatology as part of the Nordic component of the MODPOL global climatology.

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